Linkage Between Arctic Climate Change and Midlatitude Weather

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Atmospheric bridge linking Arctic sea ice to Eurasian cold weather

Figure 4 shows the simulated sea level pressure (SLP) and zonal-mean vertical structure differences between light and heavy snow runs for early summer. The model simulated June SLP anomaly patterns well capture its strong projection on the negative NAM phase as identified in the observations, although the significance level of the statistical analysis is relatively smaller than that shown in the observational data because of the small number of model ensembles. The June SLP anomaly patterns are also similar to the results of Overland et al. (2012). At the same time, rising motion occurs over around 50\textdegree N, while subsidence occurs over subpolar latitudes contributing to subarctic lower- to midtropospheric warming. In July, the rising motion moves northward over around 60\textdegree – 70\textdegree N, and subsidence extends to the entire Arctic, causing Arctic warming in the lower-to-middle troposphere. These results are consistent with and reinforce the observational and dynamic results analyzed above (Figs. 1c and 2): that is, earlier spring snowmelt leads to anomalously negative SLP over Eurasia and positive SLP over the Arctic, which has strong projection on the negative phase of NAM. In late summer, however, Eurasian snow cover is completely gone and feedback from decreased sea ice becomes more prominent, which may amplify the deceleration of the subpolar jet originally forced by earlier snowmelt (Fig. 3d), leading to a persistently and strongly negative NAM-like atmospheric circulation anomalies. Summer zonal-mean wind anomalies and tropospheric warming over the Arctic associated with the June Eurasian SCE and September Arctic SIE are also remarkably similar (not shown). This negative NAM is marked by strong easterly anomalies (deceleration of the subpolar jet) over the subpolar region, forming surface cyclonic anomalies over northern landmasses and anticyclonic anomalies over the Arctic Ocean (Figs. 1c,d). The intensified surface anticyclonic circulation favors sea ice transport via transpolar drift and export out of the Arctic Ocean (Ogi and Wallace 2007), which in turn contribute to Arctic sea ice loss (Fig. 5). It shows a pronounced reduction of sea ice occurring in all shelf seas where September sea ice exist.
Arctic amplification: A spatial pattern shift

Note:
Winter: No sea ice and snow retreat induced albedo feedback

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Arctic Oscillation and Arctic warming

AO-driven temperature change do not capture the warming pattern shift, or Arctic amplification, or warm Arctic-cold Eurasia.
Atmospheric circulation dynamics: A spatial pattern shift and the Arctic Rapid change Pattern (ARP)

The rapidly changed Arctic from the mid-1990s to the early 2000s provide an opportunity to detect this circulation change signal.

Zhang et al., 2008
What physics or dynamics does ARP represent?
ARP enhances Arctic-lower latitude interactions

provided a shortcut of atmosphere and ocean heat transport into the central Arctic from the midlatitude

Heat transport regressed onto winter ARP index (surface - 850 hpa)

re-circulate cold polar air to the midlatitude from Arctic

Surface wind stress regressed onto winter ARP index

Zhang et al. (2008)
Negative polarity of ARP has caused the shift of the warming pattern and sea ice retreat

- Amplified warming over the central Arctic Ocean, and cooling over Eurasia.

- Sea ice retreat over the Barents and Kara Seas.

Zhang et al. (2008)
Occurrence of ARP during recent years

Increased frequency of the extremely negative ARP phase.
Tropospheric warming and follow-up stratospheric warming in early 2016

There is an accelerated increase in tropospheric warming since the 1990s.

Simon Wang 2017
PDF of CAI Anomaly - Conex (Blue) and Trex (Red) for DJF (solid) and MAM (dotted)

- Decreased storminess in winter
- Increased extreme storm events

Eurasia
Changes in Northern Hemisphere Winter Storm Tracks under the Background of Arctic Amplification

Jiabao Wang, Hye-Mi Kim*, and Edmund K. M. Chang, JC

- Upper left: A weakening in the NAST and a northward shift of the NPST
- Upper right: An increase in the negative phase of the NAST. An increase in the poleward displaced NPST under the impact of Arctic warming and La Niña
- Lower left: Arctic warming and La Niña influence the changes in storm tracks via modulating baroclinicity
High PV delivers uncertainty to mid-latitudes

Sato et al. (2017, JGR-O)

(a) ACC Z300 (20–60°N, 110–170°E)
- CTLf
- OSEf

**Asian case**
- Higher skill & smaller spread
- Lower skill & larger spread

Upper PV was far from East Asia at the initial time, and traveled long distance

(b) ACC Z300 (20–60°N, 260–320°E)
- CTLf
- OSEf

**US case**
- Low skill & small spread
- Low skill & larger spread

Upper PV was close to Northern US, and traveled southward
Summary

- Selection of analysis metrics can influence understanding and interpretation of physics;
- Two-way linkage between the Arctic and midlatitude should be considered when selecting analysis metrics;
- Scale connection/interaction could be next step to understand occurrence of extreme events in light of impacts of Arctic climate change on midlatitude large-scale atmospheric circulation.